



**TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.**

# TARDEC Mobility Modeling & Simulation

**CASSI/Analytics – Dynamics & Structures Team**

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# Part 1: What We Do

## Life Cycle Modeling & Simulation Support

- Acquisition Support
  - Construct Virtual Technology Demonstrators
  - Develop automotive performance requirements
  - Write M&S content language of the Request For Proposal
  - Participate in the Source Selection Evaluation Board
- Field System Support
  - Configuration changes
  - Waiver requests
  - Safe Use Range of Operation

## • Examples of Mobility Events

- Vehicle stability
- Ride quality
- Durability
- Maximum grade
- Maximum side slope
- Turning radius
- Wall climbing
- Gap crossing
- Braking distance
- Lane change
- Dead engine steer
- Steer characteristics
- Maximum speed
- Design loads
- Design sensitivities
- Water/Fuel transport



Multi-Body Vehicle Dynamics

## Side Slope



TiltTable-Standard.wmv

## Durability



ah32big.wmv

## Lane Change

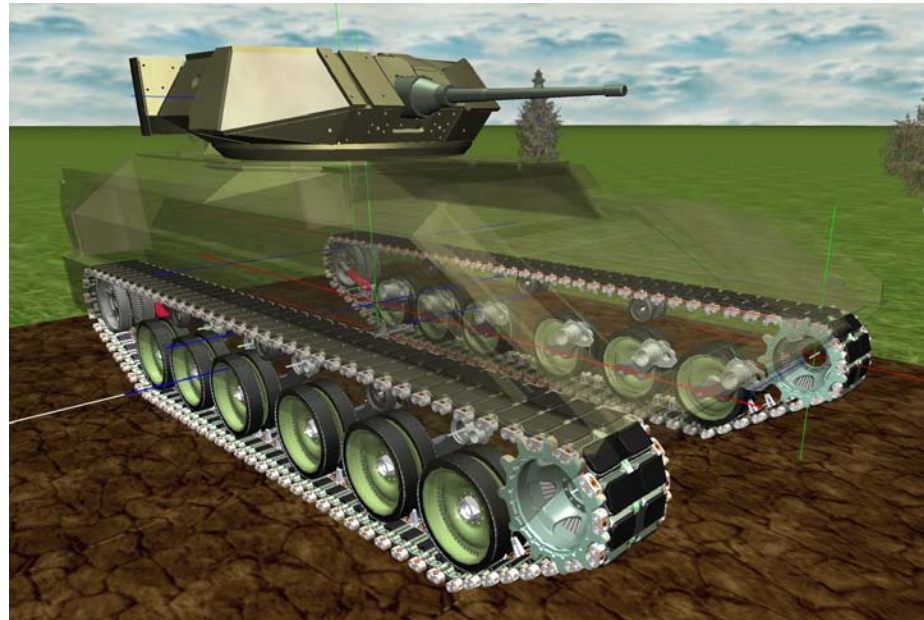


tan16700a-frontview.wmv

## Braking



Brake-LSAC-40mph.wmv



**FE-Based Vehicle Dynamics**



OPSEC\_SegmentedTrack.avi



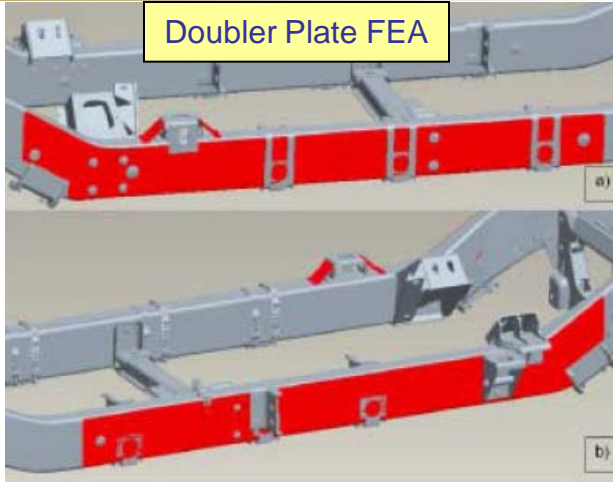
**Fluid-Structure Interaction**



OPSEC\_TankerTruck\_LaneChange.avi

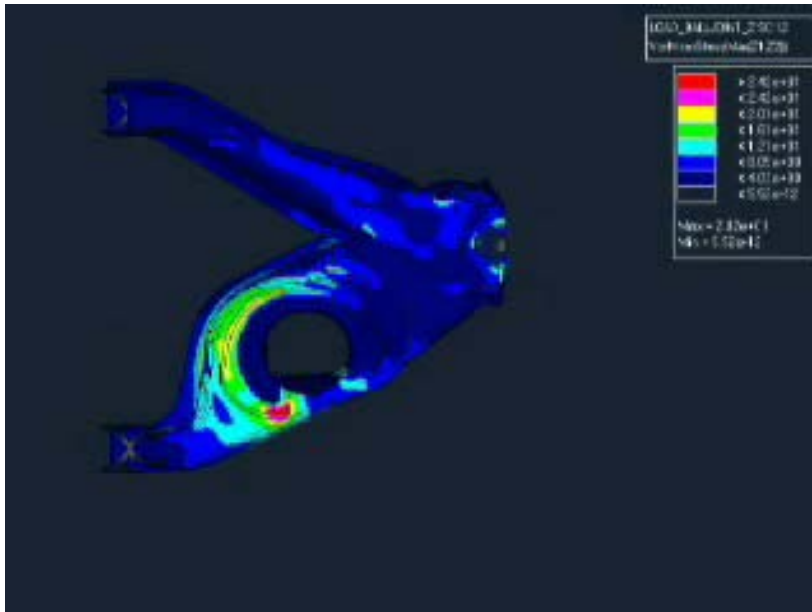
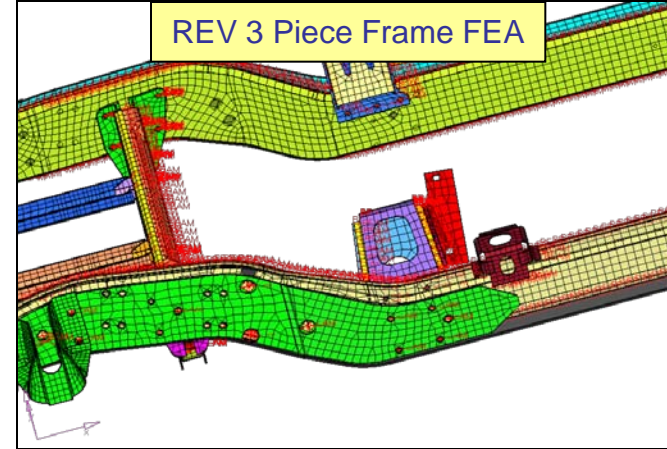


Doubler Plate FEA



## Armor Effects on M1114 Frame Integrity

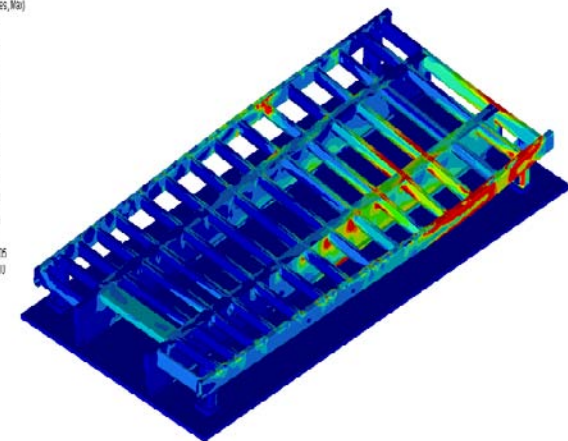
REV 3 Piece Frame FEA



M1114 Lower Control Arm

## Structural Integrity

Contour (Analysis System)  
 Stress (vonMises, MPa)  
 Max = 3.36e+05  
 Min = 0.00e+00



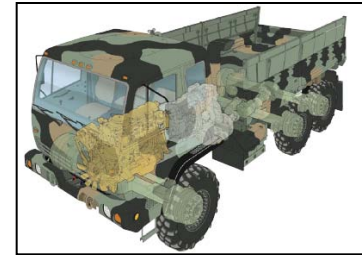
Finite Element Analysis



ASV



MRAP



FMTV



FTTS



HMMWV



GCV



JLTV



M2



M915



Small Robot



APD

## Part 2: Strategic Topics – Current & Future Needs

- Nonlinear flexible MBD
- Terramechanics
- Tracked vehicle modeling
- Tire modeling
- Terrain profiling
- Structure geometry modeling
- Active control systems
- Robotic vehicle modeling
- Nonlinear materials
- Contact, Impact, Friction, Discontinuity
- Probabilistic design
- Constraints, Recursive, Adaptive
- Stability, Robustness
- Multi-physics, Multi-scale
- MBD, FEM, Hybrid
- Implicit, Explicit, Adaptive, Hybrid
- Real-time efficiency
- Offline accuracy
- Parallel computation
- Software benchmark
- Verification & Validation

- **Develop a Standard Vehicle Dynamic M&S Framework**
  - Build models, simulate events, assess performance, report results
  - Automatic design sensitivities, optimization, and confidence limits
  - Archive models, results, and reports
  - Common pre/post-processor independent of commercial software library
  - Benchmark new software by plug and play
  - Integrate CAD, FE, MBS
  - Adaptively choose generalized coordinates or recursive
  - Ability to run symbolic or numeric
  - Choice of serial or parallel computation
  - Selection of real-time or offline simulation
  - Built-in verification and validation
  - Perform MFO
  - Utilize industry standard tools
  - Emphasize new research
  - Endorsed by industry as a standard vehicle dynamic M&S framework

- **Small Robot Mobility M&S**
  - How do we model small robots
  - What are the important model parameters
  - How to model terramechanics
  - Is the knowledge of large vehicle mobility scalable
  - How do we integrate sensors, controls, and actuators
  - What needs to be the requirements
  - What scenarios and events to simulate
  - How to simulate in real time accurately
  - What software is suitable for simulation
  - How do current M&S software perform
  - How to test hardware and correlate M&S results
  - How to improve robot reliability
  - What are academic/industry standards and references

- **Cross pollinate with other disciplines**
  - Robotics
  - Biomechanics
  - Wind energy
  - Space research
  - Railway
  - Molecular dynamics





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**Human Centered Modeling and Simulation Needs**



**Overview:** Researchers and Quad members of TA2 should develop modeling methodologies to;

- Improve seat comfort and reduce Soldier fatigue in tactical and combat vehicles.
- Improve ingress/egress modeling methods particularly in roll-over situations [egress].

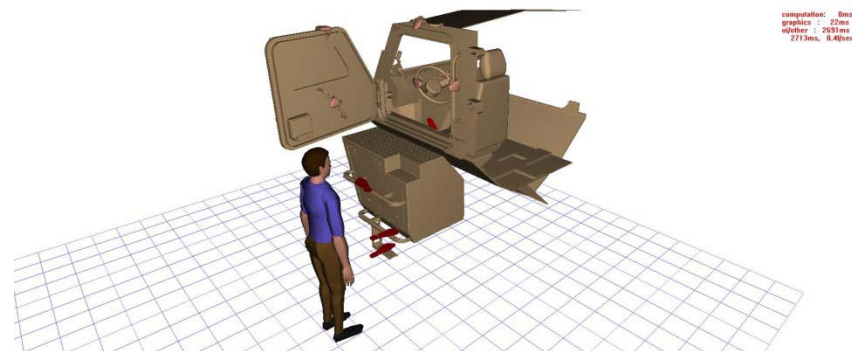


*No body armor*



*With body armor*

**Rationale: Seat Comfort.** In the process of rapidly procuring Mine Resistant vehicles, some of them were designed with poor ride comfort due to stiff suspensions combined with uncomfortable seats. As a result, there have been many complaints from theater about the roughness of the ride and the comfort of the seats prompting the Army to take an active role in improved seat comfort.



**Rationale: Ingress/Egress.** Currently satisfying Soldier ingress/egress requirements require numerous human subjects trials involving real vehicles, mockups, and Soldiers. This consumes significant resources and time. Simulation methods can reduce the resource burden and permit more trade studies.